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CONTINGENCY RESPONSE FOR RAPID EVALUATION OF RADIOLOGICAL POLLUTION FROM A SPACE VEHICLE LAUNCH ACCIDENT

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Abstract

CONTINGENCY RESPONSE FOR RAPID EVALUATION OF RADIOLOGICAL POLLUTION FROM A SPACE VEHICLE LAUNCH ACCIDENT.

In fulfilling the Environmental Protection Agency's responsibility for providing surveillance and evaluation of environmental pollution, the Agency's Eastern Environmental Radiation Laboratory provides a contingency response capability in support of certain space vehicle launch operations. The plan described provides for the rapid evaluation of environmental elements in the public domain adjacent to space launch facilities. The plan is implemented during the final phase of launch operations of space vehicles carrying SNAP-27 devices which contain a significant quantity of ^{238}Pu. Teams are deployed to intercept a computer-predicted fall-out pattern along available access roads and according to the distribution of the population. Such deployment is complicated by the presence of 750 000 people observing the launch from the roadsides, thereby clogging major traffic routes during the final countdown phases. Monitoring equipment includes FIDLER detectors and appropriate equipment to determine airborne and surface contamination. Radio communications provide a centralized control room with data from on-site, off-site and airborne monitoring units for evaluation. The accumulated data are interpreted by a team of experts who review the entire radiological picture and then make recommendations to the pertinent authorities for necessary action. Although several agencies work together to fulfil numerous responsibilities, the system has operated smoothly in the support of Apollo 12, 13 and 14. The success of the system is dependent upon the co-operation between the many agencies involved such as the Atomic Energy Commission, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and State and local health officials.

1. INTRODUCTION

The manned Apollo space mission series conducted by the National Aeronautics and Space Administration (NASA) is to explore the lunar surface. A radioisotopic thermoelectric generator was included in the Apollo Lunar Surface Exploration Package to provide electrical power to experimental components and their associated telemetry systems left on the lunar surface. The heat for the generator was supplied by the decay energies of approximately 45 000 curies of plutonium-238 in the form of PuO_2 [1].

With due respect for the consequences of releasing this activity, special design features were incorporated to provide the generator with sufficient containment integrity to survive launch accidents and to preclude an environmental release. Although the probability of releasing radioactivity (due to a launch accident) to an offsite environment was extremely low, it was deemed prudent to prepare a

contingency response capability for a period of 6 hours just prior to and during the launch when the system was most vulnerable to an accident [1]. The offsite portion of this contingency preparation was assigned to the U. S. Public Health Service, Bureau of Radiological Health, and subsequently was delegated to the Southeastern Radiological Health Laboratory (SERHL) [2]. Although this Laboratory has been assigned to the U. S. Environmental Protection Agency (EPA) and renamed Eastern Environmental Radiation Laboratory (EERL), it has retained this delegated responsibility.

2. OBJECTIVES

Since the probability of a real contingency was extremely low, it was necessary to establish a balance between the degree of preparation to afford proper public protection and safety, and reasonable expenditure of funds commensurate with the probability of the contingency. The proper balance was selected as that amount of operation which could:

(1) Rapidly detect the presence of unusual concentrations of ^{238}Pu in the nearby public domain.

(2) Delineate the area most significantly affected.

(3) Determine the degree of contamination relative to Radiation Concentration Guide (RCG) for public exposure.

(4) Provide guidance as to any immediate protective action which might be indicated to reduce hazards to the offsite population.

(5) Provide a basic organization which could be augmented to perform environmental measurements for any extensive recovery activities.

These objectives became the responsibility assigned to EERL. EERL was also assigned the responsibility for providing liaison between the State and local health agencies and NASA, the agency of prime responsibility.

3. PLANNING CONSIDERATIONS

In order to accomplish the assigned objectives, a number of specific elements dictated these major planning considerations:

(1) The only radionuclide of concern was ^{238}Pu which was in the chemical form of PuO_2.

(2) From the extensive accident models, analyses revealed that the prime hazard to public health would be an inhalation hazard. If ^{238}Pu were reduced from the larger fuel form to respirable particle sizes (an event with low probability), it could result in unacceptable concentrations in air for the general public in limited areas. Once this activity had been deposited on the ground, the PuO_2 seemed to present very little chance of biological uptake due to its chemical behavior [1].

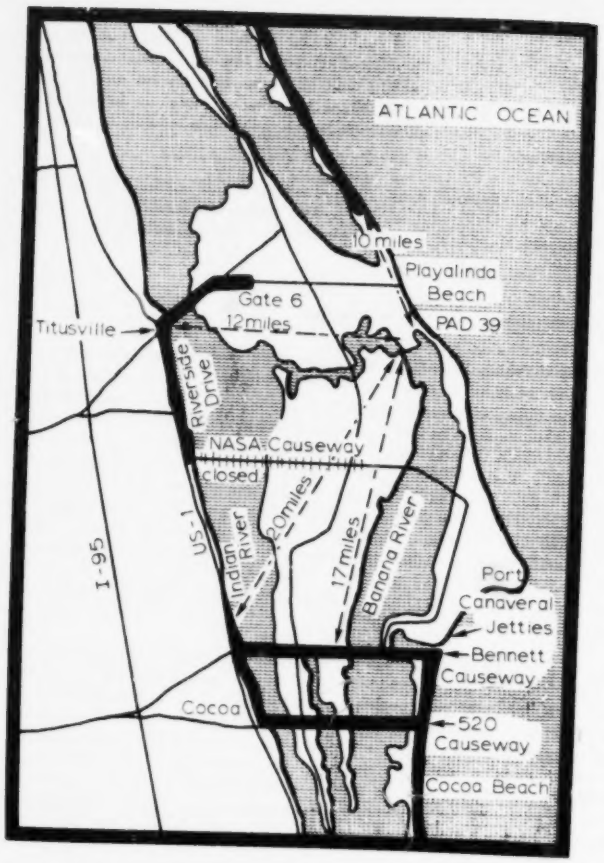

FIG. 1. Cape Kennedy area; darkened area represents public viewing areas.

(3) The public area potentially affected is a coastal region with lagoons, rivers, bays, islands, marshes and urban and rural areas, all mingled so as to limit access to a relatively few land routes. The Atlantic Ocean to the east is separated from the Florida mainland by a chain of north-south elongated islands and the Indian River. Residential areas are developed on many of the islands and along the mainland, again with north-south orientation (see Figure 1).

(4) Since the terrain is relatively level, the launch facilities are visible from numerous points along the major transportation routes. With the extensive public interest in space activities, large numbers of people congregate at these vantage points to view the launch. Figure 1 illustrates the extent of public vantage points from which as many as 750 000

people have viewed one of these operations [3]. Special consideration was given to the effect of spectators clogging highways and inhibiting the mobility of offsite monitoring units. Island traffic can be expected to be heavy for as long as five hours after a launch. There is no estimate of what these conditions would be like following a launch accident.

(5) The wind patterns in this location can change rapidly due to local land-sea effects and frontal passages. Such rapid changes dictate a requirement for rapid mobility of monitoring units.

4. PLANNING FIELD OPERATIONS

Initial planning involved selection of instrumentation to provide optimum capability to detect environmental contamination from ^{238}Pu. In the rugged semitropical environs, typical alpha monitoring instruments, although sensitive, were deemed less than desirable due to their vulnerability to failure or breakage and due to their limited detecting area. The FIDLER (Field Instrument for Detection of Low Energy Radiation), developed by Dr. J. F. Tinney of Lawrence Radiation Laboratory, was chosen as the primary instrument for field monitoring (Figure 2). It could readily detect the 17-keV x-ray from ^{238}Pu decay and could effectively monitor an extended plutonium-contaminated surface at a distance of 12 inches. Therefore, it would "see" about one square meter with a detection sensitivity of better than 1 $\mu Ci/m^2$ for evenly distributed activity [4].

Since the prime hazard had been identified as an airborne problem, high volume air sampling capability was also an important element of the monitoring capability. This was provided by utilizing a Staplex-type air sampler powered from a portable a.c. generator. Four-inch glass-fiber filters were used as the collection media. A standard alpha scintillation survey meter was also included in the equipment inventory to provide added sensitivity to field assessment of the air samples as well as back-up capability to the FIDLER. Other equipment is listed in Table I.

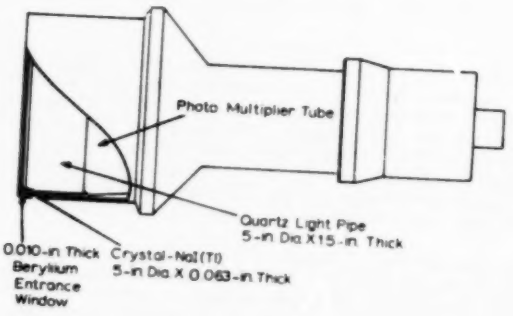

FIG. 2. FIDLER probe [4].

TABLE I. RADIOLOGICAL TEAM EQUIPMENT CHECKLIST

2 map sets	1 can motor oil for generator
12 air sampling forms	1 funnel
12 monitoring log sheets	1 spark plug
1 clipboard	2 grease pencils
12 sampling tags with wire	1 flashlight
1 FIDLER, PRM-5, and strap	1 machette
1 PAC1SA	1 electric lantern
1 generator and propane bottle	1 can mosquito spray
1 electrical extension cord	1 pair snake protectors
2 air samplers	1 spade
1 air sampler box with legs	2 pair gloves
1 pocket knife	1 set pruning shears
1 vice-grip pliers	2 rolls masking tape
1 pliers	5 "D" cells
1 10-in. crescent wrench	1 first-aid kit
1 12-in. ruler	1 15-volt battery (for speaker on PRM-5)
1 large screwdriver	10 large plastic bags
1 small screwdriver	
6 glass fiber filters and 6 glassine envelopes	
2 large-mouth bottles w/shipping containers	
2 small-mouth bottles w/shipping containers	

To cope with the flexibility requirements and complicating traffic problems, seven mobile monitoring teams were established with communication capability to a radiation control center. This number of teams compensates for the loss of two to three teams being "locked" into a position by spectator traffic, leaving four teams to work a predicted affected area. Local experience had already indicated that even police escorts cannot effectively move through the typical traffic entanglements experienced in this area.

With two qualified monitors comprising a team, sufficient trained personnel were available to provide expanded coverage in an interim period following the contingency until additional personnel could arrive for extended monitoring operations. In such a case one team member could be replaced by a non-radiologically trained assistant to either double the number of field teams or to allow for rest during extended monitoring operations.

Communications were an additional essential preparation. Each team was provided with a portable radio with a channel used only by radiological monitoring units to communicate to the radiation control center. This center is described later.

All the onsite and offsite radiological communications were incorporated on the one radio channel to coordinate all radiological activities without the interference from other launch and contingency operations. All the field units were directed through this system and were provided information on the progress of the operation. Such techniques can guide an individual monitor as to the significance of his information to the overall problem. If a team lost radio contact they were instructed to call by public telephone one of several telephone numbers at the center.

5. THE ORGANIZATION

To provide for orderly functioning of this operation and to ensure that the operational objectives were met, the detailed responsibilities were organized and distributed as follows:

(1) Operations Director was the official representative of the Environmental Protection Agency (EPA) in the radiation control center who provided liaison and coordination between State and local health agencies and the radiation control center; informed higher EPA authorities of contingency activities; expressed EPA policy decisions to NASA; and held overall responsibility for the EPA contingency operation. This director also worked with the Operations Officer and Assistant Operations Officer to interpret the significance of reported data.

(2) Operations Officer was in charge of selection and training of teams for the operations. During actual operations he directed the field monitoring units and served as the radio communicator.

(3) Assistant Operations Officer assisted the Operations Officer in communications, recording data and other duties as directed.

(4) Team members were chosen to represent a broad spectrum of capabilities such as instrument calibration and repair, field radiochemical procedures for rapid evaluation of environmental samples, sample shipping and control, radio dispatching, and program direction. Such specialities could become the nucleus of a supporting role for any expanded monitoring program.

6. PRELIMINARY COORDINATION

The early stages of planning identified the major objectives for the contingency preparedness and assigned these to an appropriate agency. Having received the assignment for the offsite area, the EERL developed coordination to include the Florida State Health Department Radiological Health Program and any local health officials who might be involved in any real contingency. The Florida State Health Department was advised of the progress of plans once the essential objectives had been selected. Such information allowed this State agency to develop realistically appropriate planning activities of their own. The State Health Department also briefed other State agencies such as the highway patrol and the civil defense organization. Their combined evaluation indicated that no supplemental planning was required of these other agencies.

As the contingency plans neared completion, the county health officers of the nearby counties were briefed by a representative from the State Health Department, EPA and NASA. Each agency's designated contact was clearly identified as were the roles that each agency had to fulfill. The plans provided that a county health officer needed only to contact the EPA Operations Director for any information he required. In reverse, all contingency management recommendations and information were directed from the radiation control center through the same EPA Operations Director to the county health officer. Such procedures did not change but only supplemented the county health officer's relations with the State Radiological Health Program.

7. PLAN IMPLEMENTATION

Approximately six days prior to launch the Operations Officer, Assistant Operations Officer and new team members arrive at a field office established at Patrick Air Force Base, some 20 miles south of the Kennedy Space Center. Here equipment is checked for operational status, calibrated and prepared for issue. Security and other administrative details are handled. New team members are acquainted with the operation and directed to familiarize themselves with routes to frequently used monitoring sites.

Three days before launch, experienced team members arrive, equipment is issued, and team pairings are assigned with radio call signs. Area communications are then thoroughly checked to identify any problems. FIDLERS are enclosed in plastic bags to prevent contamination. On the day preceding launch, each team confirms its ability to operate.

The Operations Director arrives three days prior to launch to ensure that the program is operational and to reestablish contact with appropriate authorities. It is necessary that any problem areas within the operation be identified and resolved prior to launch day.

On launch day the Operations Director, Operations Officer and Assistant Operations Officer report to the radiation control center. This is a communication center set up by NASA to direct all radiological monitoring activities both onsite and offsite. The center incorporates a team concept with members from the NASA safety and medical departments, NASA health physics contractor, U. S. Air Force, U. S. Atomic Energy Commission (USAEC), Environmental Science Service Administration (ESSA) and Environmental Protection Agency (EPA). Initially all the communications are checked. At six hours prior to launch the offsite teams are directed to positions selected on the basis of a computer-predicted dispersion pattern calculated from local weather data and interpreted by the ESSA representative.

At their monitoring sites the teams are directed to take background instrument readings and set up their air sampler generator system and verify that the system will operate properly. The monitoring sites are selected to be relatively unobtrusive and collectively to embrace the predicted deposition pattern. Teams are periodically updated on the progress of the launch countdown and are repositioned as weather conditions change.

8. ACTIVITIES IN EVENT OF LAUNCH ACCIDENT

Since offsite areas are 10 miles or more from the launch complex, it is expected that a significant time period will elapse between an accidental release and its arrival to an offsite monitoring site. This allows the teams to receive advance notice and to begin monitoring activities prior to a cloud arrival.

At the announcement of a launch accident, teams start air samplers, draw environmental samples and begin continuous monitoring with the FIDLER. Teams periodically are requested to report FIDLER readings. Sudden increases are to be reported as they occur. During this time, radio discipline is strictly maintained by the Operations Officer to ensure orderly and accurate reception of field data.

In the accident models developed for the safety analysis report, sudden area contamination would occur almost simultaneously with airborne activity. Instrument responses are expected to demonstrate large increases as opposed to slow, gradual increases. As positive detection responses are reported, teams are moved to concentrate on the predicted affected area so as to delineate the extent of the problem. The Operations Director evaluates the data and decides on the official recommendation for appropriate action to be taken offsite.

Data from the onsite activities, meteorological measurements, and offsite monitoring are composited in the radiation control center. Recommendations for protective actions are developed by the staff in this center. Implementation of these recommendations is accomplished by the appropriate responsible agency. Other agencies support by providing their distinct technology, equipment and manpower as needed.

9. EXPERIENCE LESSONS

From the development and implementation of this contingency preparedness program it was recognized that a major key to a successful plan was the coordination and involvement of all the civil agencies which might be called on during the contingency. Such coordination kept them informed and afforded them input to the contingency plans. Information passed along during the development of plans reaps cooperation from these units when it is required. Each civil unit knows its own system and can identify the most efficient and effective way to relate to another agency's contingency plan.

Of particular interest in this operation was the simplification of the problem, as it was limited to one radionuclide and primarily to one hazard, an inhalation exposure. Such conditions allowed the planners to select highly specific instrumentation and monitoring procedures for greater sensitivity and to disregard many problems posed by broader scope accidents, such as multiple radionuclides involving all types of radiations or high external radiation exposures.

The role of communications was emphasized in this operation. This is an element common to all types of emergencies. An evaluation of the system's ability to handle a heavy flow of information demonstrated the importance of radio discipline to regulate the transmission of pertinent data at a rate which assured its accurate assimilation. Such discipline was maintained on the radio by requiring all radio transmissions to be limited to communications between a mobile unit and radio network controller at the center. In this plan all onsite and offsite units (up to 32 mobile radios) were controlled by one communicator on one radio frequency.

Twice during the implementation of this contingency preparation, wind shifts required a complete change in team deployment. In each case teams deployed to the extreme northern locations had to be relocated to points south of the site (a shift of approximately 20 miles). In spite of public congestion, such shifts were easily accomplished by requiring teams to avoid being blocked in at their monitoring sites and to select sites which offered quick access to open routes running north and south. The mobility of the teams was thus proven effective.

10. CONCLUSIONS

The implementation of this contingency preparedness plan for three space vehicle launches has increased our confidence in the ability of the plan to function effectively in a contingency situation. Through the adoption of realistic operational goals, detailed planning and appropriate specific monitoring techniques it is possible to develop an effective contingency plan. The size and cost of such an operation must be balanced with the plan's effectiveness, the probability of occurrence and the scope of the contingency.

We believe that in this operation a proper degree of preparedness was selected, resulting in a plan that could serve effectively to expedite control of an emergency radiological problem and reduce its environmental impact.

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DISCUSSION

P. KISSEL: Rapid assessment of environmental contamination is clearly the first step to be taken following a nuclear accident. The assessment should aim at the taking of protective measures, particularly in relation to the public. Several speakers at this symposium (for example Mr. Tritremmel from Austria and Mr. Shearin from the United States of America) have told us that various authorities and organizations, such as the police, fire brigade, Red Cross, etc., are called upon to co-ordinate their efforts and operations so as to take these protective measures. But in practice such measures are only possible if a single authority has the power to take immediate decisions. In the United States of America, for example, which is the authority that can take action concerning members of the public immediately after a radiation alert in the field, e.g. vis-a-vis the 750 000 spectators at the launching of a spacecraft equipped with, say, a plutonium radioisotope generator?

R.L. SHEARIN: I can say that in our contingency operation for spacecraft launching we pay particular attention to this point. During the six-hour period of operation we verify that we have communication with the local county health officer, who has the requisite authority in cases of this type. In his possession are the texts of three public announcements to cover all actions we would require, and he has agreed beforehand to accept the recommendations of the Radiation Control Center. Agencies represented

in the Center vest their authority in their representatives so as to relieve them of co-ordination duties in connection with implementing actions or making decisions. We strongly believe in working through the existing authorities.

W.G. MARLEY: It seems to me that the responsibility for taking public health action must rest essentially with either the central or the local medical health authorities of the country. In preparation for emergency action the plant management must therefore make all necessary arrangements in advance with those authorities and the other government departments concerned (such as those responsible for the quality of food and water) and with the local police, who would no doubt actually take the necessary action itself. Only if suitable arrangements are made in this way with the various authorities will the plant management be in a position to bring into action immediately the necessary countermeasures should the need arise. It is important to recognize that any medical prophylactic measures such as the use of potassium iodide must be taken only on medical authority.

G. H. PALMER: Mr. Marley has answered the question in a general manner, but it may be of use if I outline the detailed procedure on a reactor site. We have close liaison with the local authorities and in particular the chief of police, the local Medical Officer of Health, and the Ministry of Agriculture, Fisheries and Food.

The plant management has the prime responsibility for detecting and reporting an accident and advising the correct local authority organizations on what measures are appropriate following the monitoring survey program. For example, if the plant management considered that a certain section of the public should be evacuated, they would inform the police, who would then carry out the evacuation.

If medication were recommended, the Medical Officer of Health would take the necessary action according to a pre-arranged plan, after being asked to do so by the plant management. If milk were found to be contaminated, the Ministry of Agriculture representative would, on the basis of the monitoring results furnished by the plant, take the decision to ban the consumption of locally produced milk and arrange for a supply of clean milk. A supply of suitably worded notices are printed and available for distribution to farmers. At the time of detecting and declaring an emergency, the services mentioned above, i. e. police, health authorities, the Ministry and so on, would be alerted and would send to the plant representatives who would act as liaison officers with the plant management.

P. KISSEL: Perhaps I could explain briefly the situation in France. In each of the 95 Departments the authority responsible for safety precautions to protect the public, irrespective of the type of accident involved, is the Prefect, or administrative head, of the Department.

This official represents the Government, and therefore all the Ministries which might be involved, and by virtue of this fact has authority over all the public services, including emergency services and police. Thus for organizing emergency action, implementing it and co-ordinating all operations necessary in the event of an accident involving radioactivity, the Prefect has at his permanent disposal a departmental echelon of the National Civil Defence Service. This echelon not only has emergency equipment available, but is also vested with the powers necessary to carry out its task: (a) it can obtain the assistance of experts from the Central Service for Protection against Ionizing Radiations and from the French

Atomic Energy Commission, which is organized at regional level to meet the need for such assistance; (b) it can requisition all the equipment and personnel needed, no matter whom they belong to.

In short, there exists a single authority and immediate decisions can be taken, if need be, while awaiting further action requiring the advice of the experts referred to. The existence of this authority at local level is indispensable if the saving in time secured by the use of rapid methods of assessing radiation hazards is really to come into play in ensuring more thorough protection of persons living in an area where an accident occurs. I believe that this is the ultimate aim of radiation protection specialists.

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